"MODELING HYBRID PRODUCTION SYSTEMS. A POSSIBLE CHARACTERIZATION."

Authors:
Rafael RUIZ USANO
Adolfo CRESPO MARQUEZ

Dpto. de Organización Industrial y Gestión de Empresas
Escuela Superior de Ingenieros Industriales
UNIVERSIDAD DE SEVILLA
41012 - SEVILLA (SPAIN)

ABSTRACT

The paper describes the process of modeling, under the system dynamics point of view, a production planning problem which is managed using a hybrid "push/pull" approach.

The results obtained from the hybrid model are compared, for several production scenarios, to those obtained for push and "pull" schemes separately. Computational results are presented and discussed under financial and non-financial perspectives.

INTRODUCTION

Some advisable configurations for hybrid control schemes in production were suggested by Karmarkar (Karmarkar U.S., 86, page 26). The possibility of building a hybrid system considering the utilization of a kanban approach for those stages in the factory which have short and predictable lead times, and a "push" (MRP) approach for the ones with a long and variable lead time, is one of the ideas that Karmarkar proposes to develop.

This paper, departing from a three stages kanban system model already validated (O'Callaghan R., 86), introduces the new control schemes which lead to the hybrid "push/pull" configuration, evaluating and measuring the performance of the new model for scenarios in which it should be more efficient.

THE INITIAL PULL MODEL

The kanban system original model is basically the one described by O'Callaghan, shown in figure 1.

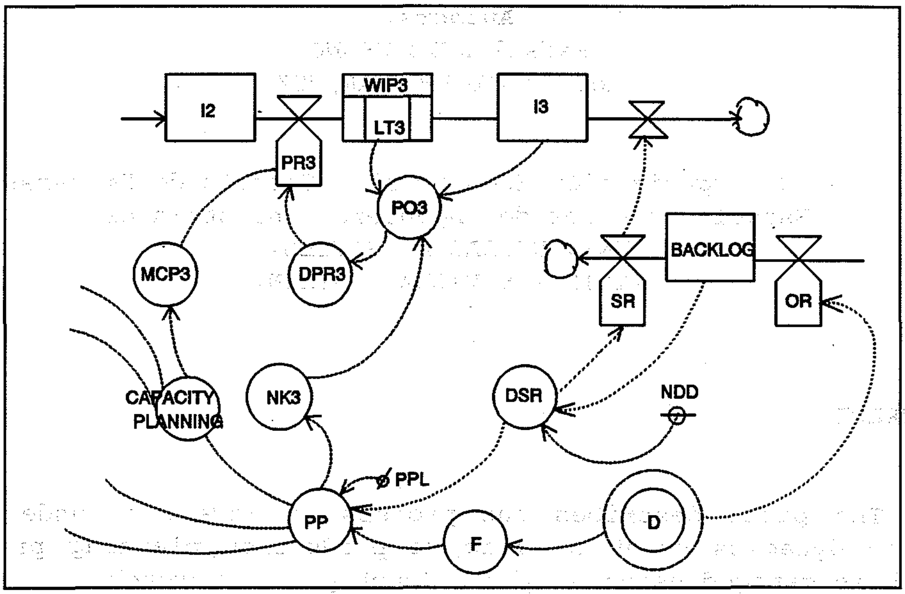

Figure 1. The kanban system model.

In that model, for every stage of the process, production is ordered by means of the remaining kanbans (production orders) at the end of every kanban cycle, such as:

Production Rate(PR)=Production Orders(PO)/kanban cycle(IT)

Moreover, in every stage, the production orders can be calculated as follows:

POi = NKi * UCi - Ii - WIPi

where:

NKi : Number of kanbans for the stage number i.
UCi : Units per container (or per kanban)
Ii : Inventory placed at the end of the stage.
WIPi: Work in process in the stage.

The number of kanbans is calculated every time a planning period starts and according to the production plan selected for that period of time.

NKi = (PP/UCi)(LTi+ITi)(1+SSi)

where:

PP :Production plan for the particular planning period.
LTi:Lead time of the stage number i.
ITi:Kanban cycle for the stage number i.
SSi:Safety period considered for the stage i.

The production plan in the original model is estimated taking into account both the orders backlog, and the demand forecast.

PP = X * F + (1-X) * DSR

Where:

X : Weight factor.
F : Demand forecast.[1]
DSR: Desired shipment rate = BKL/NDD

BKL: Orders backlog
NDD: Normal delivery delay

The only one exogenous variable in the model is the market demand. The production plan, as determined by the number of kanbans, introduces the effects of variations in the market demand for every step of production. These effects are updated every planning period.

The kanban system, by itself, can be considered as a mixture of push and pull effects. The process control is predominatelly "pull", but a "push" effect is occasionally introduced into the system, adding or substracting kanbans every time a new production plan is calculated.

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[1] The dynamo ecuation for this forecast would be one such as: F.K=SMOOTH(D.K,TD) where TD is the time considered for the forecast.

THE INITIAL PUSH MODEL

The fundamentals of the push pattern used for building the hybrid control scheme are described by Crespo & Ruiz-Usano (Crespo A. & Ruiz-Usano R., 92). The model's most important feature is the method of calculation used to achieve the net requirements of every stage of production (i.e. production rates), which causes a "push" effect in the system according to variations in demand. That means that there is a short delay in the transmission of the market evolution to the production stages.

Gross requirements of the last stage = PP

NRi = GRi + (SSi - Ii)/TAI
GRi = NR_{i+1}

Where:

NRi : Net requirements of the stage number i.
GRi : Gross " " " .
TAI : Time to adjust the inventory.
PP : Production plan.

This idea follows the basic structure shown by Morecroft (Morecroft J., 83) for an MRP system dynamics model.

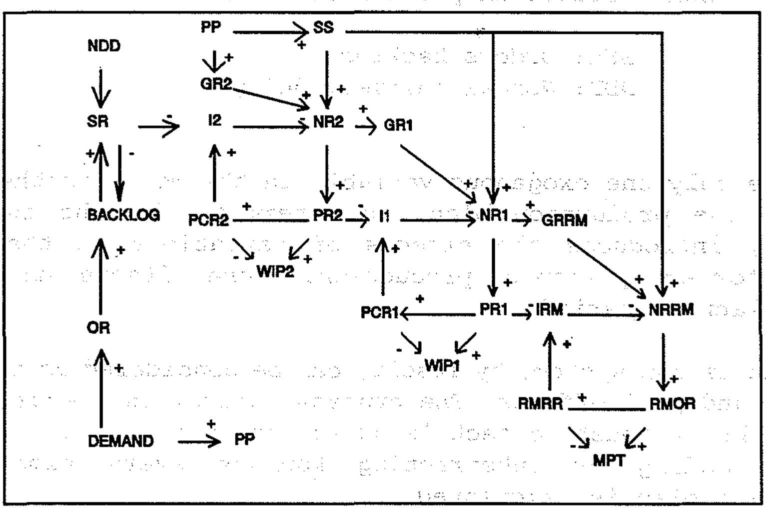

Figure 2. The "push" MRP system model.

THE HYBRID CONTROL SCHEME

In the hybrid control, the "push" approach is used to manage the first stage of production, considered in this case the Procurement Stage, before the assembly line. The lead time of this stage, which is equal to the suppliers delivery time, will be longer than the lead times considered for the stages 2 and 3 (subassembly and assembly processes) managed by the "pull" kanban system.

According to the previous paragraph, an interface between the pull system in assemby and the push system in procurement, must be established.

The model presented here calculates the net requirements of all production stages, taking into account the quantity of inventory remaining after each stage. These calculations will signal a requisition rate for raw materials to suppliers, but will never indicate a value to set assembly production rates. In fact, subassembly and assembly production rates may be calculated following the normal kanban procedure.

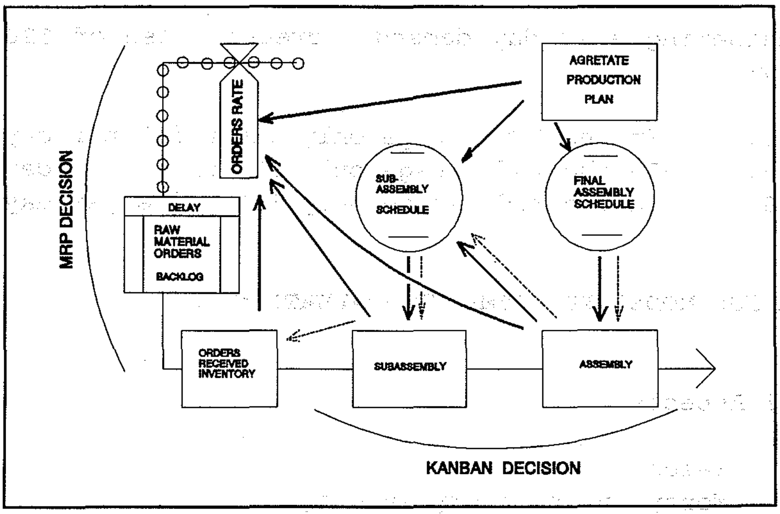

Figure 3. The Hybrid approach.

THE SCENARIOS

All scenarios will consider that

LT1 = 2 Days. Procurement
LT2 = .5 Days. Subassembly
LT3 = .5 Days. Assembly

CAPACITY CONSTRAINT = 120 units per day in all stages.

Demand increase

sc.1. Step of 10% after de 2nd. day.
sc.2. Step of 20% after de 2nd. day.

Breakdown in one stage

sc.3. One-day breakdown in 1st. stage.
sc.4. One-day breakdown in 2nd. stage.
sc.5. One-day breakdown in 3rd. stage.

Bottlenecks

Considering a 20 day demand increase pulse of 120 units/day:

sc.6. In the 1st. stage only 110 units per day.
sc.7. In the 2nd. stage only 110 units per day.
sc.8. In the 3rd. stage only 110 units per day.

CRITERIA FOR MODEL PERFORMANCE EVALUATION

Financial Aspects

c.1. Sales
c.2. Money in inventory (average)
c.3. Money turnover

Non-Finantial Aspects

c.4. units in inventory (average)
c.5. time in the system for one unit (average)

EXPERIMENTAL RESULTS

SCENARIO 1- sc.1.	Financ.	Financ.	Financ.	Non-Fi.	Non-Fi.
	C.1.	C.2.	C.3.	C.4.	C.5.
Kanban Model	21870	25,091	847,1	456,56	4,3001
Hybrid Approach	21870	28,046	757,51	412,35	3,8868
SCENARIO 2- sc.2.					
Kanban Model	23410	29,435	762,2	431,42	3,871
Hybrid Approach	23410	31,063	717,55	410,87	3,6875
SCENARIO 3- sc.3.					
Kanban Model	20000	24,865	805,07	432,66	4,3265
Hybrid Approach	20000	27,829	721,02	390,69	3,906
SCENARIO 4- sc.4.					
Kanban Model	20000	24,452	820,89	439,29	4,3907
Hybrid Approach	20000	27,652	725,53	393,16	3,9297
SCENARIO 5- sc.5.					
Kanban Model	20000	24,391	823,5	440,18	4,3991
Hybrid Approach	20000	27,764	720,38	390	3,9
SCENARIO 6- sc.6.					
Kanban Model	21600	28,416	747,99	416,67	3,9845
Hybrid Approach	21600	30,588	691,5	390,62	3,7293
SCENARIO 7- sc.7.					
Kanban Model	21600	24,069	881,75	484,2	4,6213
Hybrid Approach	21600	26,296	609,57	449,2	4,2867
SCENARIO 8- sc.8.					
Kanban Model	21600	22,652	955	507,03	4,8285
Hybrid Approach	21600	25,331	852,24	456,31	4,3461

CONCLUSIONS

This research indicates that the utilization of system dynamics as a methodology to study production alternatives is an effective strategy for management teams. Problems can be studied according to the management perpectives most adequate for individual environmental conditions. Simulations using system dynamics present an easy way to try different solutions to various problems by means of hybrid configurations. System dynamics can also aid in the search for parameter values which contribute to the system compensation when managed with a hybrid scheme.

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